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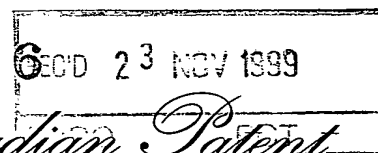
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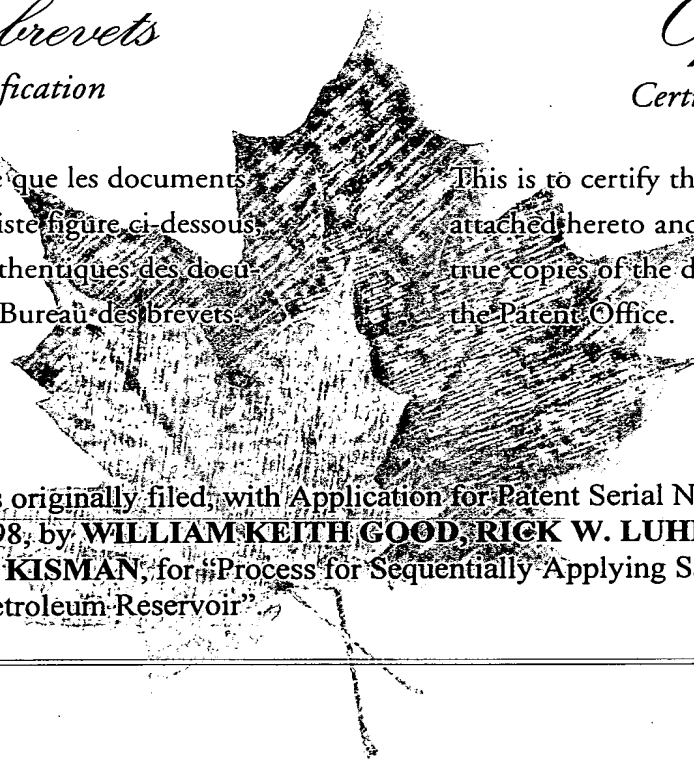


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Specification as originally filed, with Application for Patent Serial No: **2,251,157**, on
October 26, 1998, by **WILLIAM KEITH GOOD, RICK W. LUHNING AND
KENNETH E. KISMAN**, for "Process for Sequentially Applying Sagd to Adjacent
Sections of a Petroleum Reservoir"

PRIORITY DOCUMENT

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(CIPO 68)

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1 **"PROCESS FOR SEQUENTIALLY APPLYING SAGD TO ADJACENT**
2 **SECTIONS OF A PETROLEUM RESERVOIR"**

3 **ABSTRACT OF THE DISCLOSURE**

4 Steam assisted gravity drainage ("SAGD") is practised in a first section
5 of a reservoir containing heavy oil. When production becomes uneconomic,
6 steam injection into the first section is terminated. Non-condensable gas is
7 then injected into the section to pressurize it and production of residual oil and
8 steam condensate is continued. Concurrently with pressurization, SAGD is
9 practised in an adjacent reservoir section. As a result, some of the residual oil
10 in the first section is recovered and steam loss from the second section to the
11 first section is minimized.

FIELD OF THE INVENTION

This invention relates to recovering heavy oil from an underground reservoir using a staged process involving, in the first stage, steam assisted gravity drainage, and in the second stage, non-condensable gas injection and reservoir pressurization.

BACKGROUND OF THE INVENTION

Steam assisted gravity drainage ("SAGD") is a process first proposed by R. M. Butler and later developed and tested at the Underground Test Facility ("UTF") of the Alberta Oil Sands Technology and Research Authority ("AOSTRA"). The SAGD process was originally developed for use in heavy oil or bitumen containing reservoirs, (hereinafter collectively referred to as 'heavy oil reservoirs'), such as the Athabasca oil sands. The process, as practised at the UTF, involved:

-
- Drilling a pair of horizontal wells close to the base of the reservoir containing the heavy oil. One well was directly above the other in relatively close, co-extensive, spaced apart, parallel relationship.
-

The wells were spaced apart 5 – 7 meters and extended in parallel horizontal relationship through several hundred meters of the oil pay or reservoir;

- Then establishing fluid communication between the wells so that fluid could move through the span of formation between them. This was done by circulating steam through each of the wells to produce a pair of "hot fingers". The span between the wells warmed by conduction until the contained oil was sufficiently heated so that it

1 could be driven by steam pressure from one well to the other. The
2 viscous oil in the span was replaced with steam and the wells were
3 then ready for production;

- 4 • Then converting to SAGD production. More particularly, the upper
5 well was used to inject steam and the lower well was used to
6 produce a product mixture of heated oil and condensed water. The
7 production well was operated under steam trap control. That is, the
8 production well was throttled to maintain the production temperature
9 below the saturated steam temperature corresponding to the
10 production pressure. Otherwise stated, the fluids being produced at
11 the production interval should be at undersaturated or "subcooled"
12 condition. (Subcool = steam temperature corresponding to the
13 measured producing production pressure - measured temperature.)
14 This was done to ensure a column of liquid over the production well;

15 to minimize short-circuiting by injected steam into the production
16 well. The injected steam began to form an upwardly enlarging
17 steam chamber in the reservoir. The chamber extended along the
18 length of the horizontal portions of the well pair. Oil that had
19 originally filled the chamber sand was heated, to mobilize it, and
20 drained, along with condensed water, down to the production well,
21 through which they were removed. The chamber was thus filled
22 with steam and was permeable to liquid flow. Newly injected steam
23 moved through the chamber and supplied heat to its peripheral
24 surface, thereby enlarging the chamber upwardly and outwardly as

1 the oil was mobilized and drained together with the condensed
2 water down to the production well.

3 This process is described in greater detail in Canadian patent 1,304,287
4 (Edmunds, Haston and Cordell).

5 The process was shown to be commercially viable and is now being
6 tested by several oil companies in a significant number of pilot projects.

7 Now, the operation of a single pair of wells practising SAGD has a finite
8 life. When the upwardly enlarging steam chamber reaches the overlying, cold
9 overburden, it can no longer expand upwardly and heat begins to be lost to
10 the overburden. If two well pairs are being operated side by side, their
11 laterally expanding chambers will eventually contact along their side edges
12 and further oil-producing lateral expansion comes to a halt as well. As a
13 result, oil production rate begins to drop off. As a consequence of these two
14 occurrences, the steam/oil ratio ("SOR") begins to rise and continued SAGD

15 operation with the pair eventually becomes uneconomic.

16 If one considers two side-by-side SAGD well pairs which have been
17 produced to "maturity", as just described, it will be found that a ridge of

18 unheated oil is left between the well pairs. It is of course desirable to
19 minimize this loss of unrecovered oil.

20 In Canadian patent 2,015,460 (Kisman), assigned to the present
21 assignee, there is described a technique for limiting the escape of steam into
22 a thief zone. For example, if steam is being injected into a relatively
23 undepleted reservoir section and there is a nearby more depleted reservoir
24 section, forming a low pressure sink, there is a likelihood that pressurized
25 steam will migrate from the undepleted section into the more depleted section

1 – which is an undesired result. One wants to confine the steam to the
 2 relatively undepleted section where there is lots of oil to be heated, mobilized
 3 and produced. The Kisman patent teaches injecting a non-condensable gas,
 4 such as natural gas, into the more depleted section to raise its pressure and
 5 equalize it with the pressure in the relatively undepleted section. By this
 6 means, the loss of steam from the one section to the other can be curtailed or
 7 minimized.

8 The Kisman patent further teaches that pressurizing the more depleted
 9 section with natural gas has been characterized by an increase in production
 10 rate from that section, if the production well penetrating the section is
 11 produced during pressurization.

12

13 **SUMMARY OF THE INVENTION**

14 In accordance with the present invention, a novel process is provided

15 for producing adjacent sections of an underground reservoir containing heavy
 16 oil. Each section is penetrated by one or more wells completed for SAGD
 17 operation, preferably one or more pairs of horizontal injection and production

18 wells. The process comprises:

- 19 (a) injecting steam into the first section of the reservoir to practice
 20 SAGD and produce contained oil, until the steam/oil ratio rises
 21 sufficiently so that further production by SAGD from the section
 22 is substantially uneconomic;
 23 (b) then reducing or terminating steam injection into the first section
 24 and injecting non-condensable gas into the section to maintain it
 25 pressurized;

- 1 (c) continuing to produce oil from the first section while it is
2 pressurized; and
- 3 (d) concurrently with step (c), injecting steam into the adjacent
4 second section to practice SAGD therein and produce contained
5 oil;
- 6 (e) while preferably maintaining the first section pressurized to
7 substantially the same pressure as exists in the second section
8 during step (d).

9 Steps (b) and (c) constitute a post-steam windown of oil production
10 from the first section. Over time, oil production rate will drop off during
11 windown and eventually it will again become uneconomic to justify continuing
12 to produce the first section. However it may still be desirable to continue
13 maintaining pressurization in the first section to limit steam loss from the
14 second section.

15 The process provides a strategy for sequentially producing adjacent
16 sections across the reservoir. It takes advantage of gas pressurization to
17 prevent steam leakage from a less depleted section undergoing SAGD to a
18 mature, more depleted section. It also maximizes production from each
19 section by subjecting it to sequential SAGD and pressurization production
20 stages.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with the best mod of the process known to the applicants, it comprises:

(a) directionally drilling one or more pairs of wells from ground surface into a reservoir first section, to provide generally parallel, horizontal, co-extensive, spaced apart, upper and lower well portions extending through the section, and completing the wells for SAGD production;

(b) establishing fluid communication between the injection and production wells of each pair by circulating steam through both wells, to heat the span between the wells by heat conduction, and then displacing and draining the oil in the span by injecting steam through the upper injection well and opening the lower production well for production;

(c) practising SAGD in the reservoir first section by injecting steam through the injection wells and producing the produced heated oil and condensed water through the production wells while

operating said production wells under steam trap control;

(d) preparing a second adjoining section of the reservoir for SAGD production by carrying out the provision of wells and establishing fluid communication between the wells of each pair as in steps (a) and (b);

1 (e) terminating or reducing steam injection into the reservoir first
2 section injection wells and initiating natural gas injection through
3 said injection wells to increase the pressure in the reservoir first
4 section to about the anticipated steam injection pressure in the
5 reservoir second section and maintaining the pressure at about
6 this level while simultaneously producing residual heated oil and
7 steam condensate through the production wells under steam
8 trap control; and

9 (f) concurrently with step (e), practising SAGD in the reservoir
10 second section.

11 In connection with practising steam trap control with wells extending
12 down from ground surface and having riser and horizontal production
13 sections, it is preferred to operate as follows:

- 14 • measuring the downhole temperature at the injection and
15 production wells of an operating pair, using thermocouples;
16 • establishing the temperature differential between the two wells and
17 throttling the production well to maintain the differential at a
18 generally constant value (say 7°);
19 • monitoring for significant surges in vapour production rate at the
20 ground surface production separator and for surges in steam
21 injection rate; and
22 • adjusting throttling to minimize the surges.

23 Otherwise stated, a generally constant liquid rate at the wellhead is
24 maintained and the bottomhole production temperature is allowed to vary
25 within a limited range.

1 The invention is characterized by the following advantages:

2 • additional oil is recovered from the mature wells during the gas
3 pressurization stage, while simultaneously reducing steam leakage
4 from the second reservoir section;

5 • use is made of the residual heat left in the mature reservoir section;
6 and

7 • a finite steam-producing plant can be applied in sequence to a
8 plurality of adjacent sections of the reservoir, without severe steam
9 loss from a section undergoing SAGD to an adjacent depleted
10 section.

1 THE EMBODIMENTS OF THE INVENTION IN WHICH AN
2 EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS
3 FOLLOWS:

4 1. A method for recovering heavy oil from an underground reservoir,
5 comprising:

6 (a) injecting steam and producing heated oil and steam condensate
7 by steam assisted gravity drainage ("SAGD") in a first section of the reservoir
8 until it is substantially uneconomic to continue doing so;

9 (b) preparing an adjoining section of the reservoir for SAGD;

10 (c) terminating or reducing steam injection into the reservoir first
11 section;

12 (d) injecting steam and producing heated oil and steam condensate
13 by SAGD in an adjacent second section of the reservoir; and

14 (e) concurrently with step (d), injecting a non-condensable gas into
15 the first section to pressurize it and producing residual oil and steam
16 condensate from said first section.

17

18 2. The method as set forth in claim 1 wherein:

19 the first section is pressurized in step (e) to a pressure about equal with
20 the steam injection pressure in step (d).

